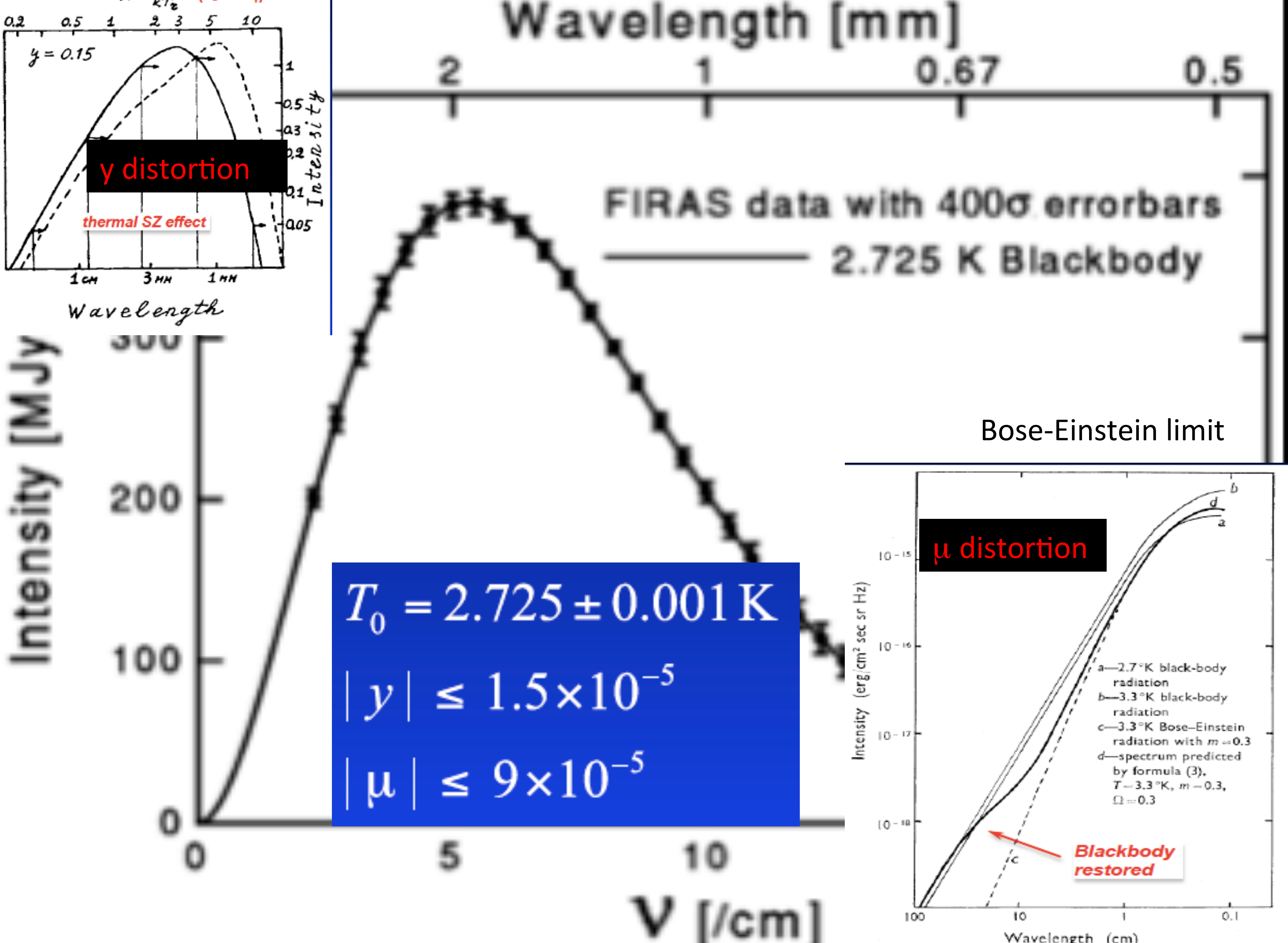
The case for spectral distortions

- Is 1000 x improvement over FIRAS sufficient or do we need a guaranteed science return?
- a dedicated spectrometric mission, no B compromise ?

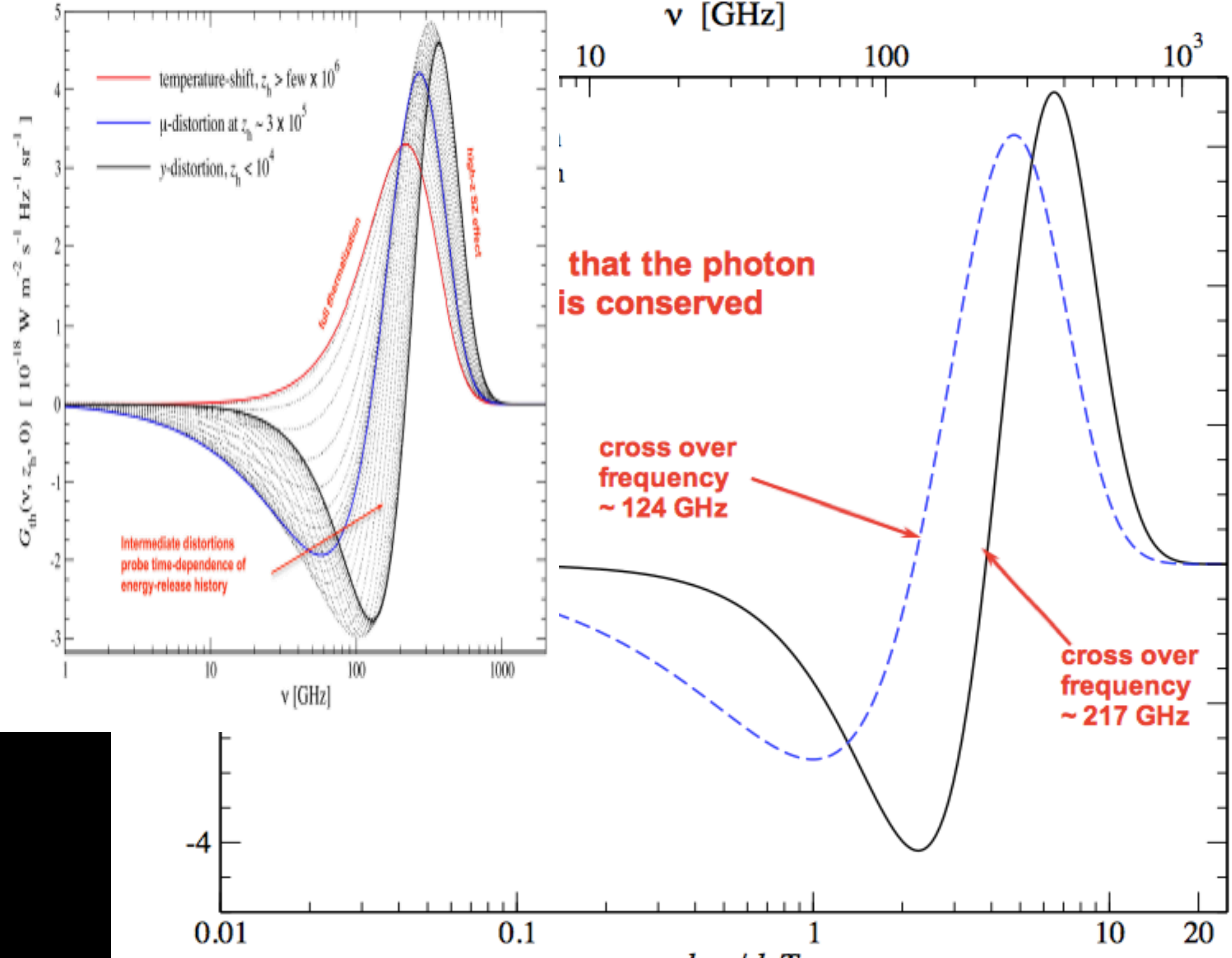


$$T_0 = 2.725 \pm 0.001\,\mathrm{K}$$

$$|y| \leq 1.5\times10^{-5}$$

$$|\mu| \leq 9\times10^{-5}$$

Sunyaev & Zeldovich, 1970, ApSS, 2, 66



temperature-shift, z_h > few x 10^6
μ-distortion at z_h ~ 3 x 10^5
y-distortion, z_h < 10^4
full thermalization
high-z SZ effect
Intermediate distortions probe time-dependence of energy-release history
$G_{th}(\nu, z_h, 0)$ [10^{-18} W m^{-2} s^{-1} Hz^{-1} sr^{-1}]
ν [GHz]
that the photon
is conserved
cross over frequency ~ 124 GHz
cross over frequency ~ 217 GHz
$x = h\nu / kT_\gamma$

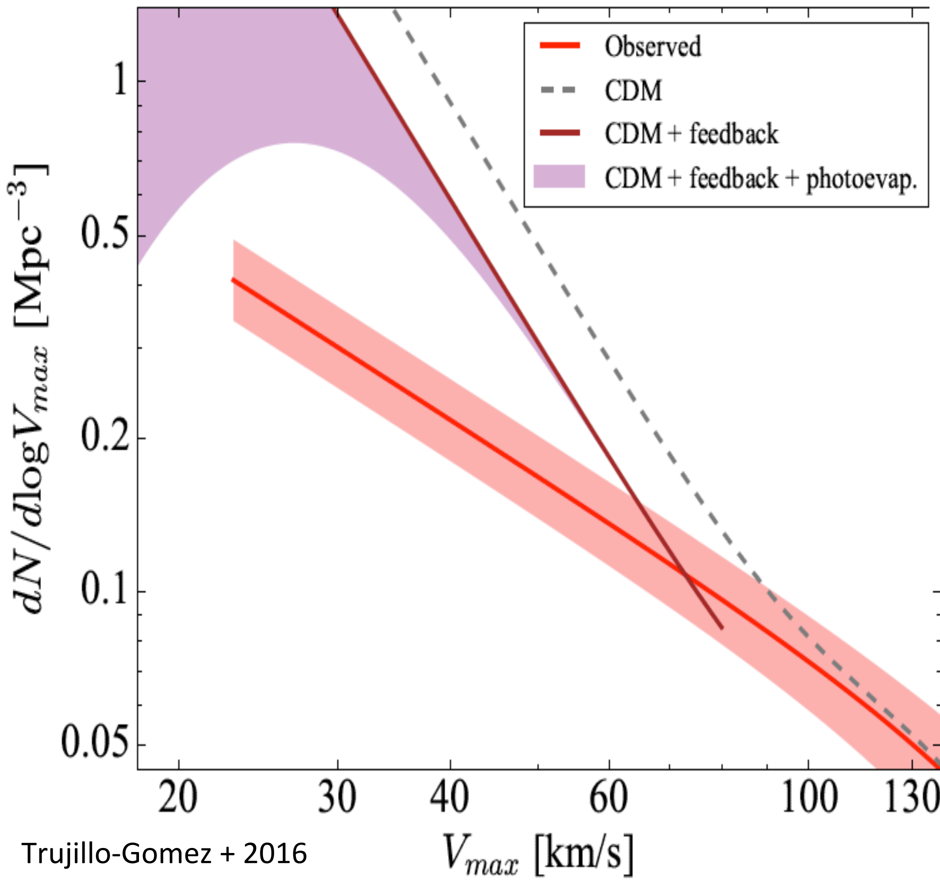
J. Chluba

Guaranteed returns to fundamental cosmology

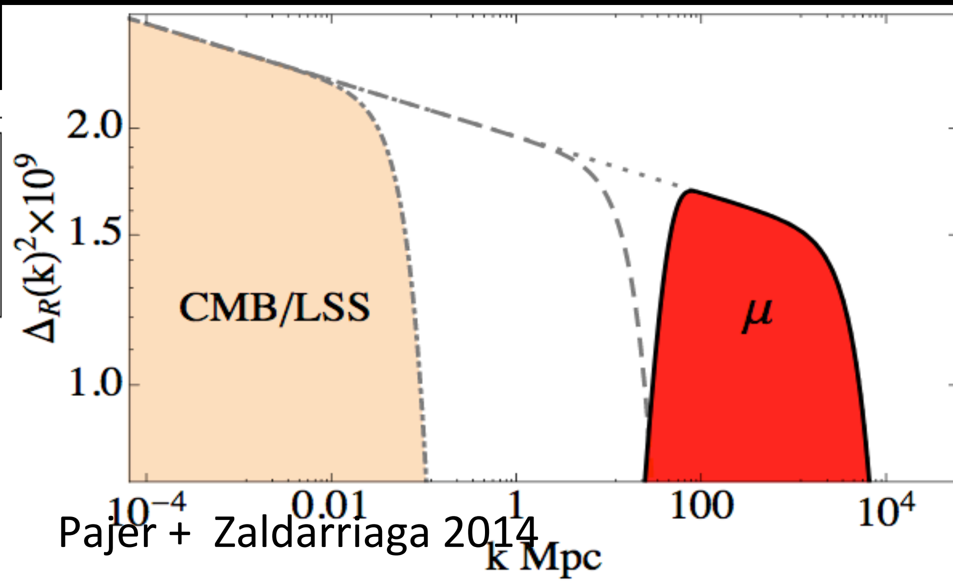
- 1. Damping of dwarf galaxy fluctuations
  $k_D=4z_4^{3/2}$ Mpc^{-1} probes 50-10^4 Mpc^{-1}
- 2. (re)combination spectral lines of hydrogen
  380000 yrs after the Big Bang
- 3. (re)combination spectral lines of helium
  long before the first stars

1. Probing dwarf galaxies

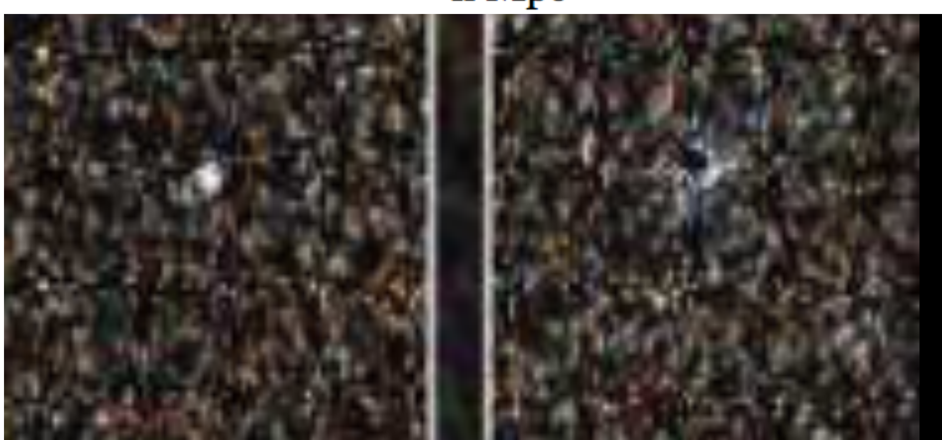
Dwarfs are a challenge to LCDM: too many predicted.
has motivated exotic dark matter, eg WDM, SIDM…

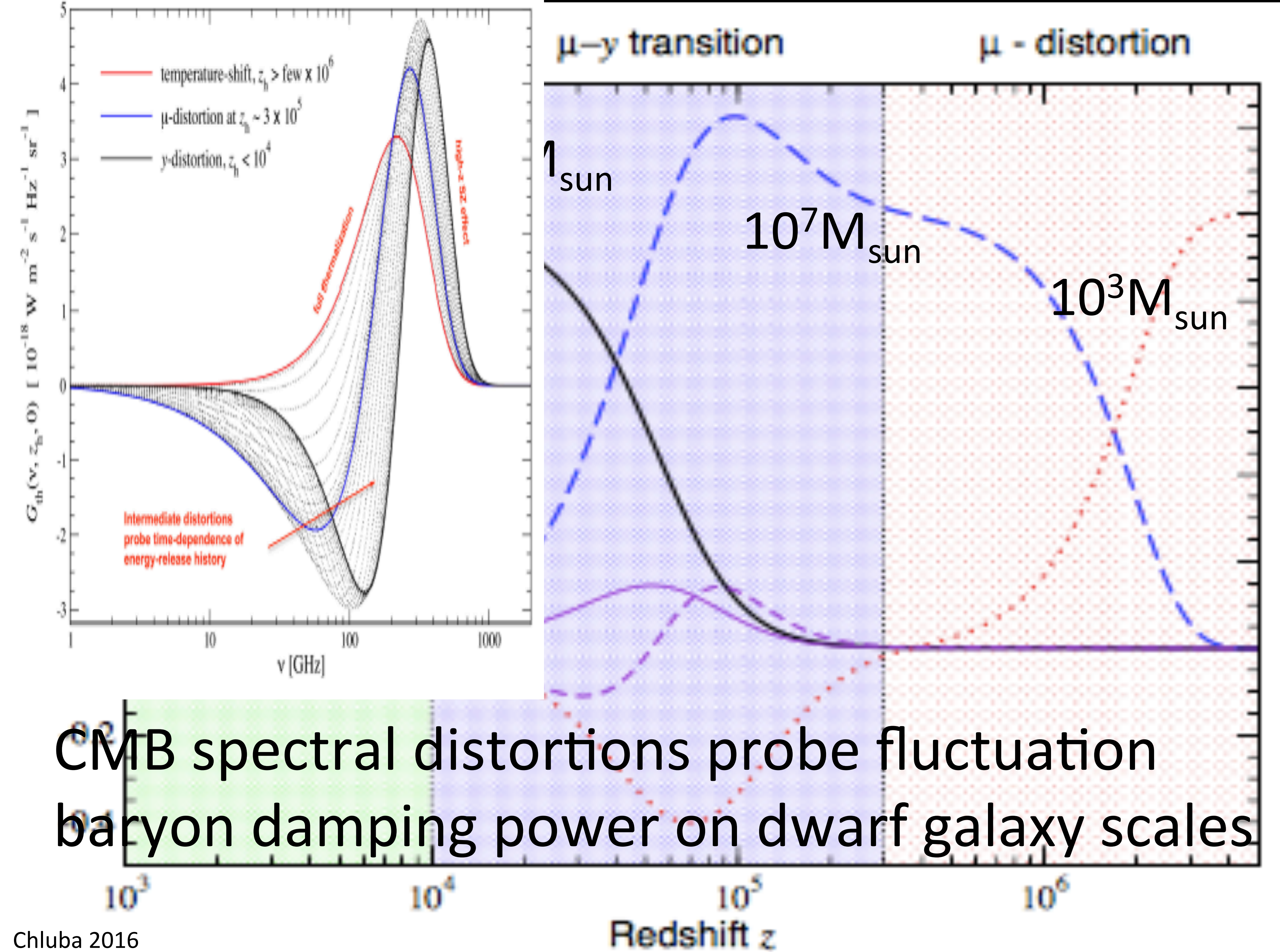


Trujillo-Gomez + 2016



Pajer + Zaldarriaga 2014



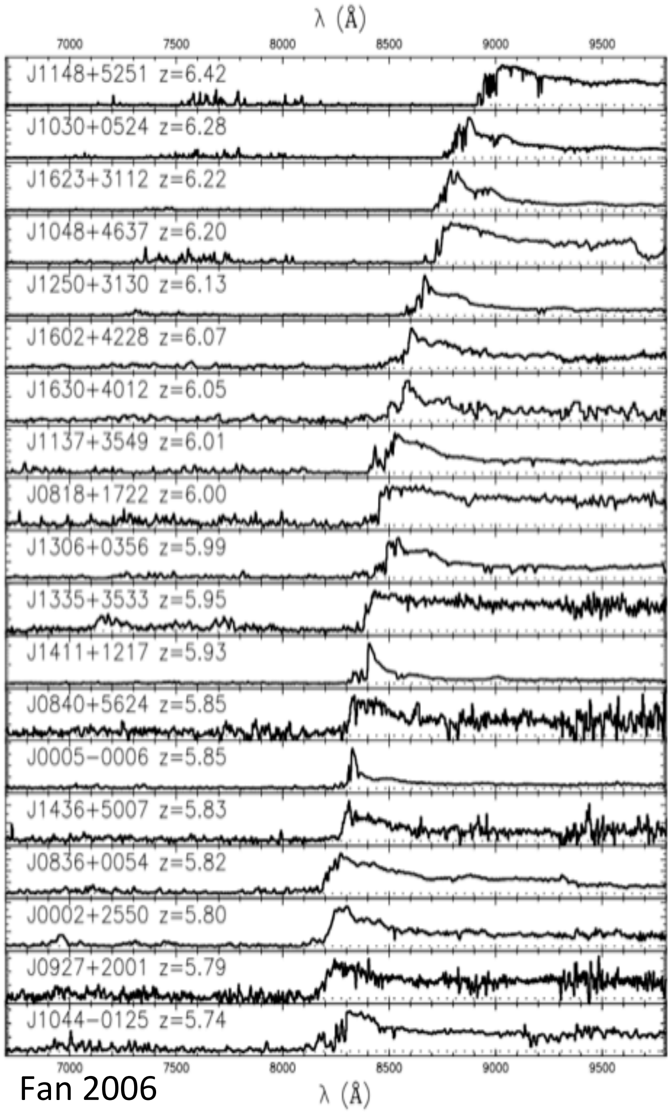


CMB spectral distortions probe fluctuation baryon damping power on dwarf galaxy scales

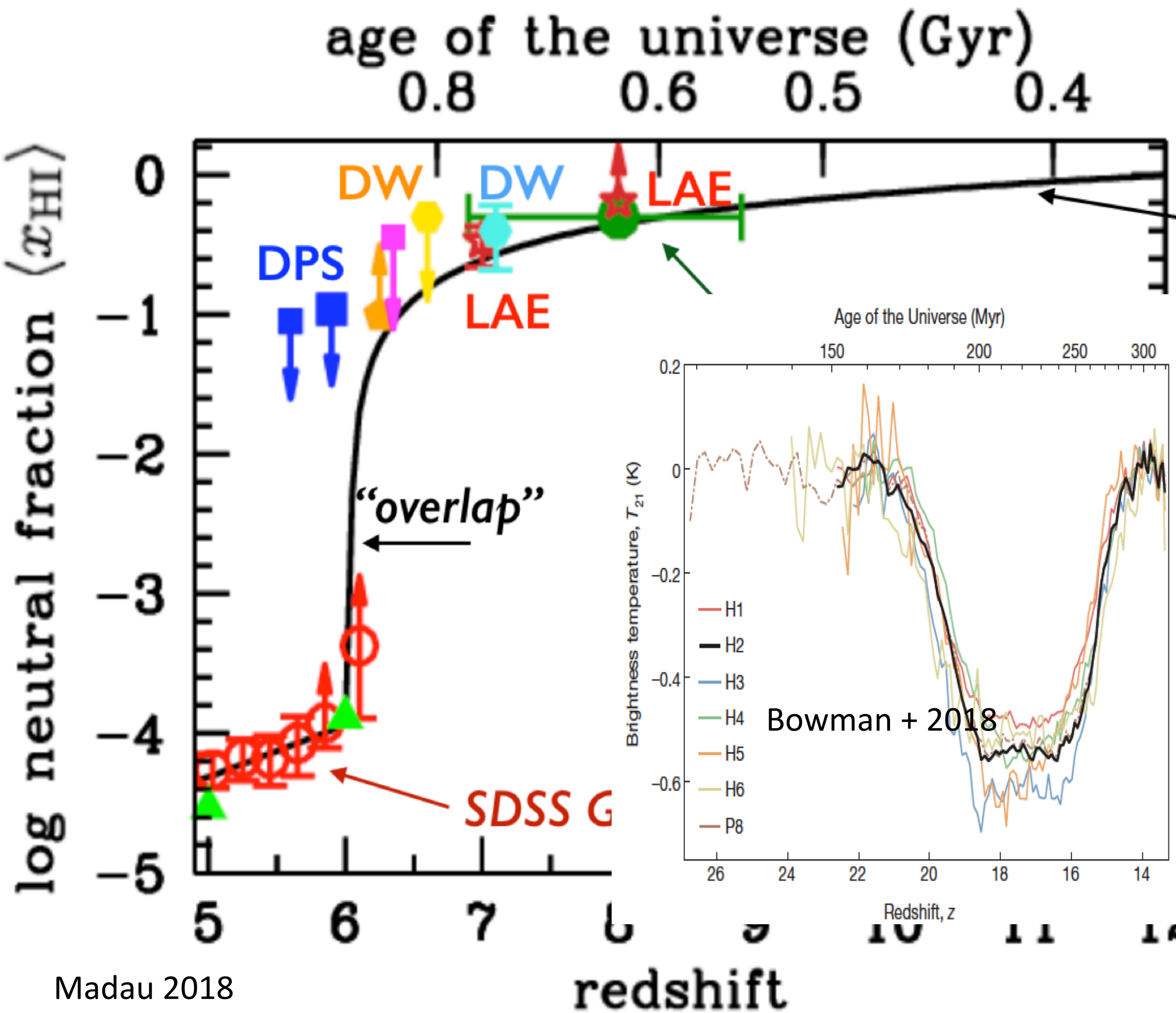
Chluba 2016

2. Hydrogen recombination lines

We measure atomic hydrogen directly to z ~8 + 21 cm maybe to z~17

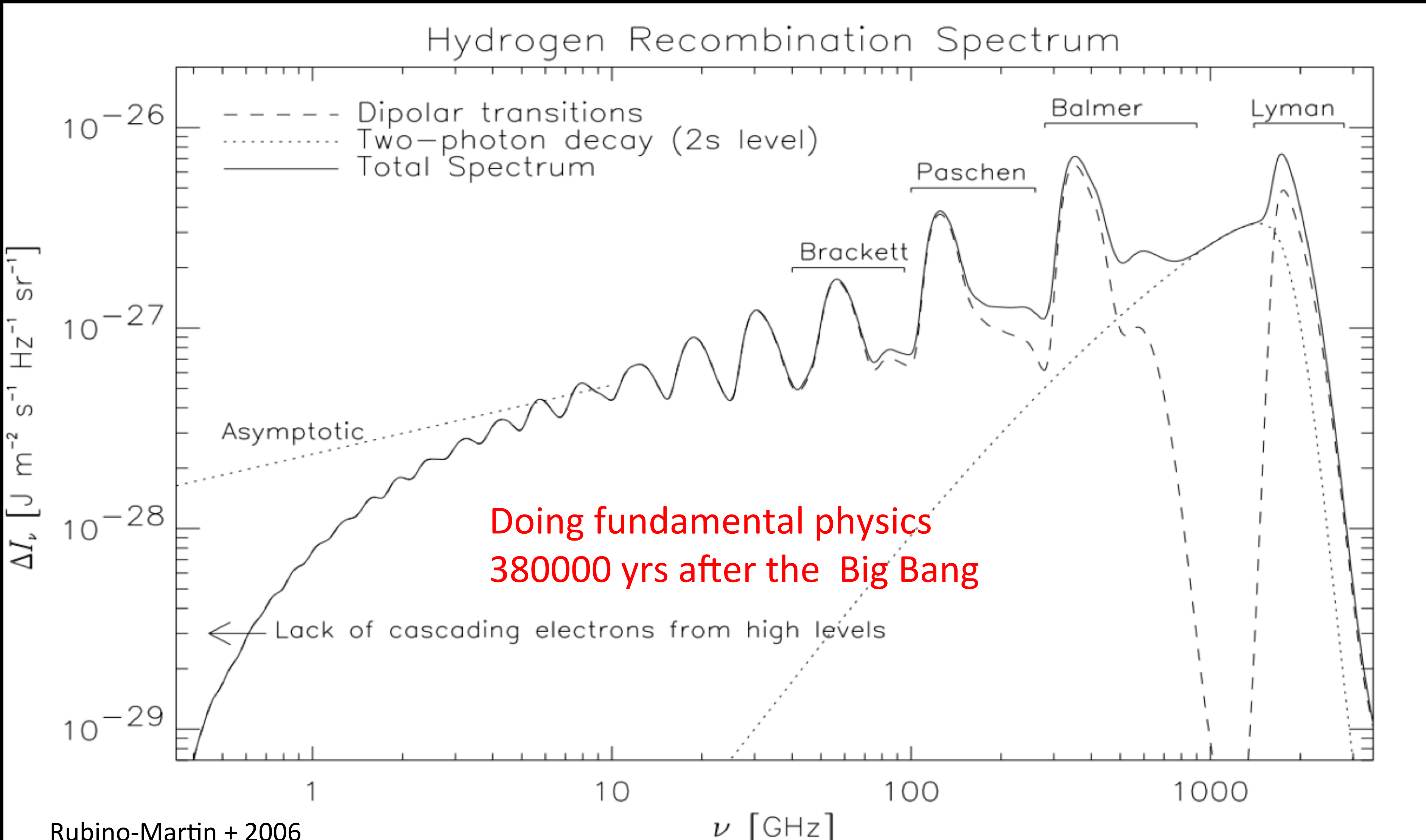


Fan 2006



Madau 2018

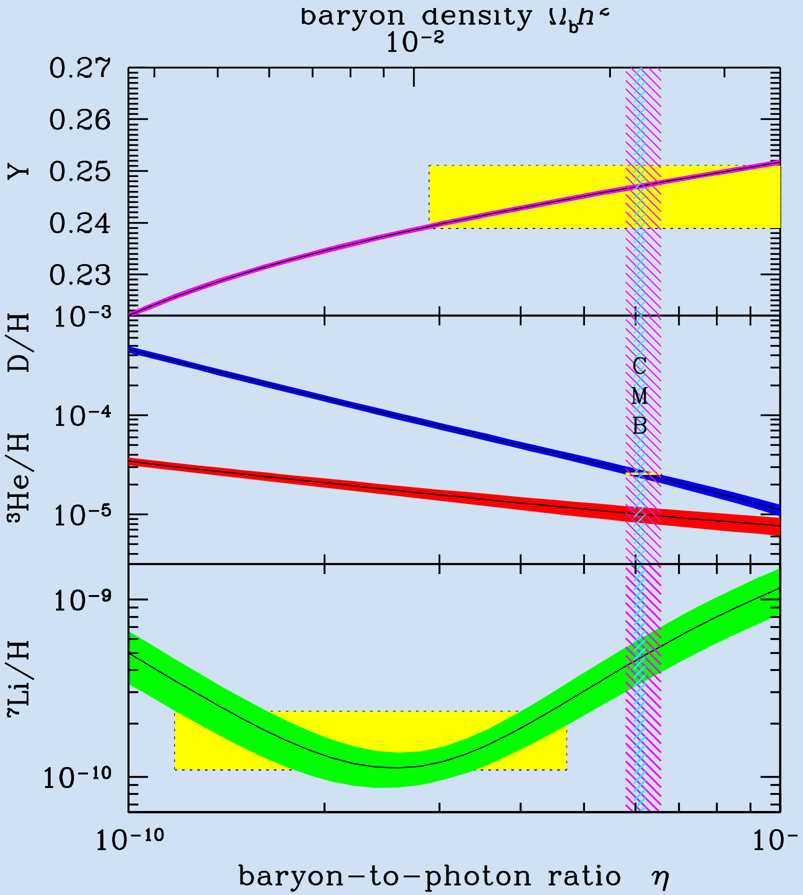
We can measure hydrogen recombination lines at z ~ 1000

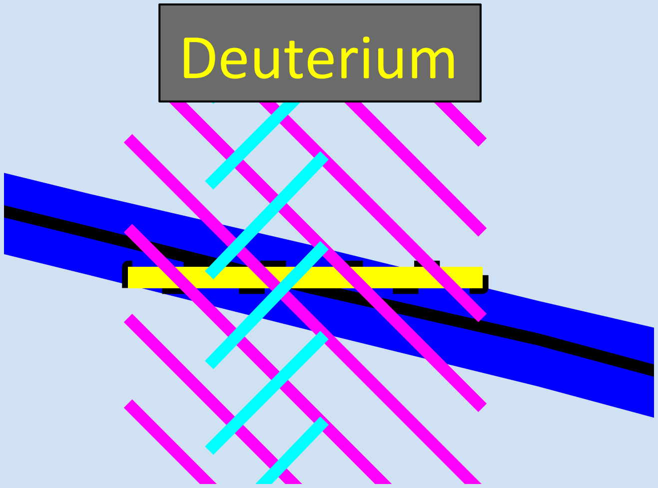


Rubino-Martin + 2006

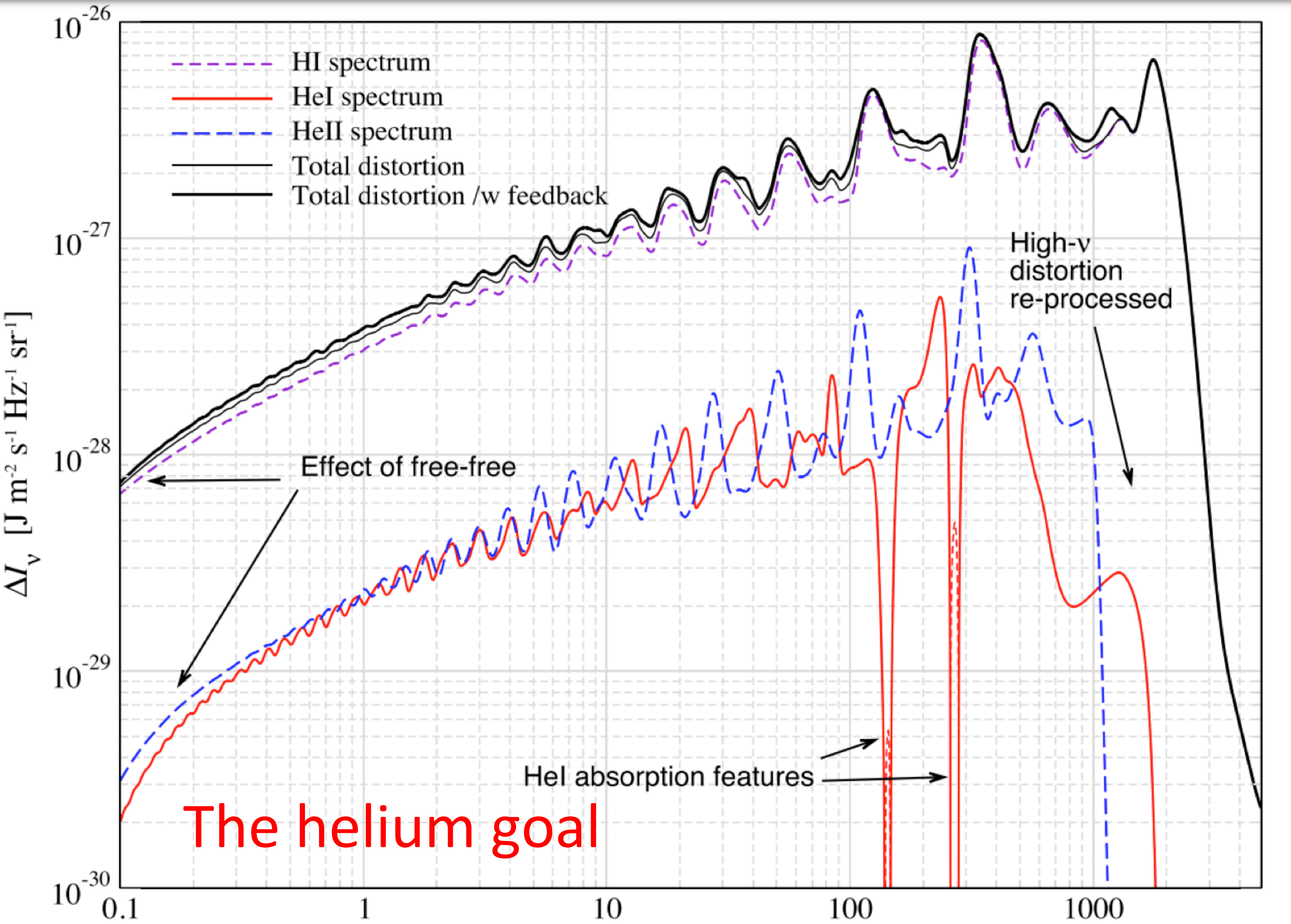
3. Probing primordial helium

- $D/H|_p$=2.569 +- 0.027 x 10^{-5} (10 determinations)
- Y_p=0.245 +-0.003 (0.2446, 0.2449, 0.2551: recent determinations)



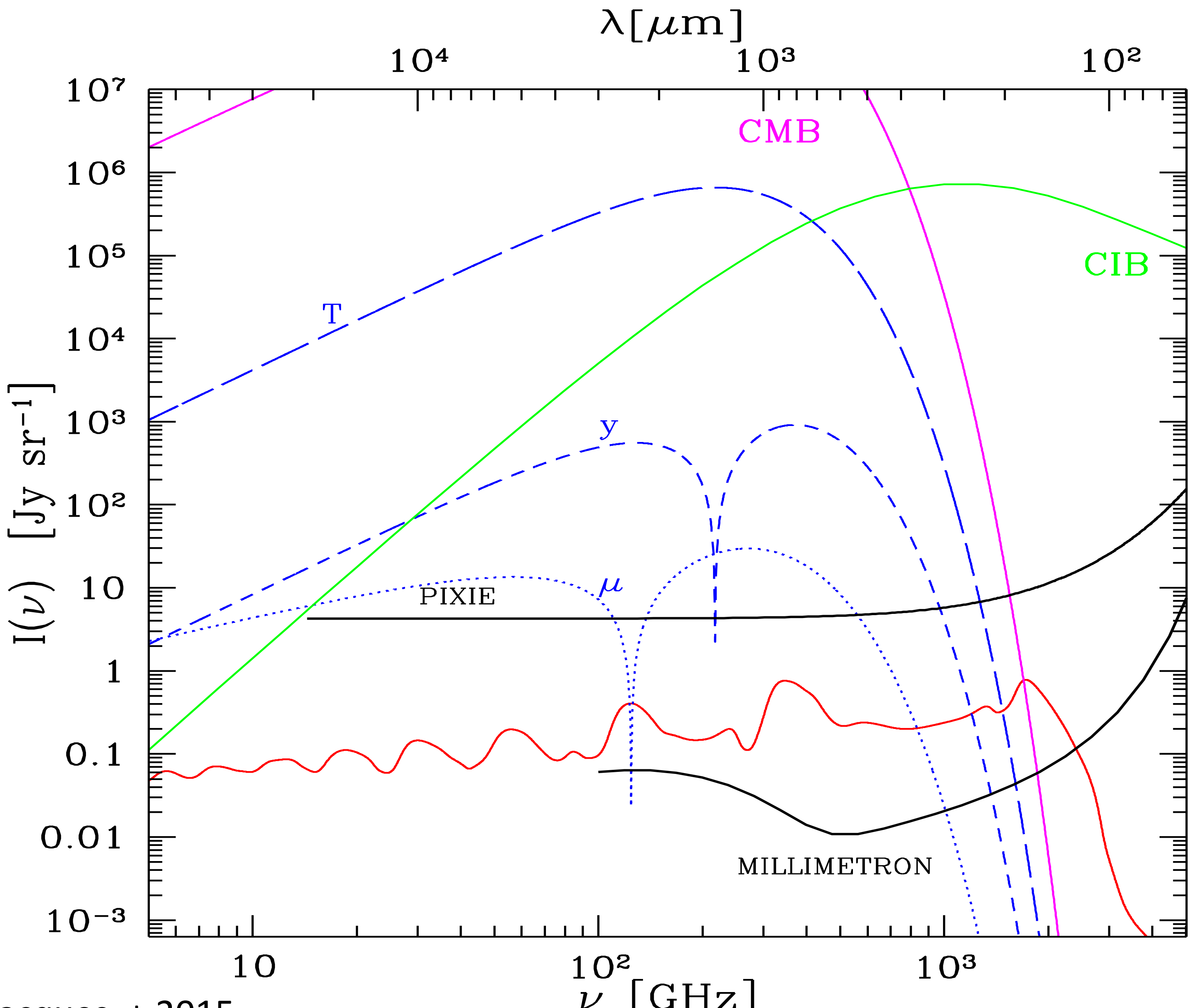


PDG, 2017



Chluba & Ali-Haimoud 2016

spectral distortion challenge to observers



Desjacques + 2015

ULTIMATE MISSION?

Gain over PIXIE via: larger telescope
many detectors
limited frequency range
single goal

	Relative to PIXIE
• Dedicated to spectral distortions	x < 2
• Add detectors: 1 → 16-100	x ~4-10
• Telescope size: (2x) 0.55m → 1x (1 – 5)m	x ~2-10
• Reduce bandwidth → 30GHz-2THz, increase f_{sky}	x < 2

X 100 would guarantee success!